

# Performance Evaluation of a Sewage Treatment Plant Using Rhodamine Tracer

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## Abstract

Biological treatment is an important and integral part of any wastewater treatment plant that treats wastewater having soluble organic impurities. Activated Sludge Process treatment technology, is one such option for treating domestic wastewater. Biological treatment using aerobic activated sludge process has been in practice over a century. Increasing pressure to meet more stringent discharge standards or not being allowed to discharge treated effluent has led to implementation of a variety of biological treatment processes in recent years. In the present study, the performance of Sewage Treatment Plant for domestic sewage was evaluated in terms of Biological oxygen demand (BOD), Chemical oxygen demand (COD), Total suspended solids (TSS), Total dissolved solids (TDS), and by water tracer studies using Rhodamine. STP showed a removal efficiency of BOD-95%, COD-90%, TSS-87%, TDS-35%. The study revealed that STP is well maintained and achieves the standards prescribed for effluent discharge by the Tamil Nadu Pollution Control Board (TNPCB).

## Keywords

*Rhodamine; Water Tracer; Activated Sludge Process; Sewage Treatment Plant*

## Introduction

Most of the metropolitan cities in India generate more than 38,254 million litres of sewage each day. Of this, it has been estimated that less than 30 per cent of what is collected undergoes treatment before it is disposed into freshwater bodies or sea[3]. As per Central Pollution Control Board rules, a city or town's municipality or water authority is responsible for collecting and treating 100 percent of the sewage generated within its jurisdiction. The level at which the sewage has to be treated depends on where it will be disposed; and treatment standards are higher for disposal into freshwater bodies than that into the sea. However, typically even where sewage treatment plants (STPs) exist, sewage collection networks are inadequate; so some portion goes for treatment and the rest flows into nallahs and drains. Sometimes wastewater stagnates in pools from which it leaches

into the groundwater table and contaminates underground aquifers[11]. Among the various wastewater treatment technologies, the most common treatment technologies preferred by municipalities are conventional activated sludge process (ASP) and sequential batch reactor (SBR). These processes are at least partly automated and designed to meet specific output quality parameters.

Tamilnadu is one of the states undergoing rapid urbanization and ranks as the most urbanized states in India. Interestingly only one-fifth of the state's total urban population is served by the sewerage system and the remaining population depends upon septic tanks or other night soil disposal systems. Study done by CPCB[15] on the performance evaluation of STPs in India revealed that the primary cause for degradation of our water resources is the pollution caused by sewage discharged from cities and towns[3]. Hence the treatment plant should be routinely checked for their performance and flaws in the treatment unit. This is usually carried out based on the removal efficiency of various wastewater characteristics and by water tracer studies.

Flow analysis and characterization in municipal and industrial wastewater facilities is part of the operational SOP. The effectiveness and efficiency of a treatment facility depends largely on adherence to hydraulic design. Dye fluorometry is used to check the hydraulic design of these systems [2,16]. The application of water tracer in wastewater treatment system is mainly carried out for operational, environmental purposes, aeration and reaeration basin mixing studies, contact chamber residence time analysis, operational, environmental purposes, and influent plume tracing, operational purposes. Among the various dyes available for fluorometric hydrologic studies, Rhodamine WT is recommended because it is easy to use and has many features which are desirable for water tracing[5], and because it is the most conservative of dyes available[5]. Studies have revealed that Rhodamine dyes can be effectively used

as a water tracer and also found application wastewater treatment systems [6,7,10].

Chennai, one of the four-mega cities in India, is the best example for pollution of surface water bodies caused by discharge from sewer outfalls. Central Pollution Control Board (CPCB) and Ministry of Environment and Forests [3] have reported that Adyar and Coovum rivers passing through the city receive wastewaters from 141 and 276 sewer outfalls, respectively. At present, there are 6 Sewage Treatment Plants in Chennai with an overall treatment capacity of 264 MLD and estimated generation of sewage in Chennai is 158 MLD [4]. Present study was carried out in Sewage Treatment Plant for domestic sewage at Alandur municipality in Chennai district of Tamilnadu State in India. The main objective of the study was to evaluate the performance of treatment based on the removal of BOD, COD, TSS, TDS and using water tracer Rhodamine.

## Experiments Design and Setup

### Wastewater Characterization

The study was conducted in sewage treatment plant at Alandur in Chennai district, Tamilnadu, India. The treatment plant treated domestic wastewater from Alandur municipality. The treatment system adopted activated sludge process for treating wastewater. Wastewater was collected from the inlet tank, aeration tank, and final outlet, was characterized for pH, Dissolved Oxygen (DO), Mixed Liquor Volatile Suspended Solids (MLVSS), Mixed Liquor Suspended Solids (MLSS), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Chloride and Sulphate as per standard methods of wastewater analysis [1].

### Performance Evaluation of STP

Samples were collected from the inlet tank, aeration tank, and final outlet and performance evaluation of STP was carried out based on the removal efficiency of BOD, COD, TDS and TSS. Further, the performance evaluation was carried out using Rhodamine-B water tracer. Rhodamine was mixed with 5 L of water and injected to the inlet of aeration tank of STP during inflow of domestic wastewater to the treatment system. The wastewater was collected at a regular time interval of 2 h for duration of 48 h and the samples were analyzed for the concentration of the tracer.

## Results and Discussion

### Wastewater Characteristics

Physiochemical characteristics of sewage from the inlet tank of STP were given in table-1. Raw sewage characteristics were above the CPCB tolerance limits for effluent discharge.

TABLE 1 CHARACTERISTICS OF THE WASTEWATER (STP)

Parameters	Influent Characteristics	TNPCB Tolerance Limits
pH	6.0-7.5	6.0-9.0
TDS	1600-2700 mg/L	2100 mg/L
TSS	300-550 mg/L	100 mg/L
COD	600-800 mg/L	250 mg/L
BOD	250-300 mg/L	30 mg/L
Chloride	1000-2000 mg/L	750-2000 mg/L
Sulphate	40-50 mg/L	2 mg/L

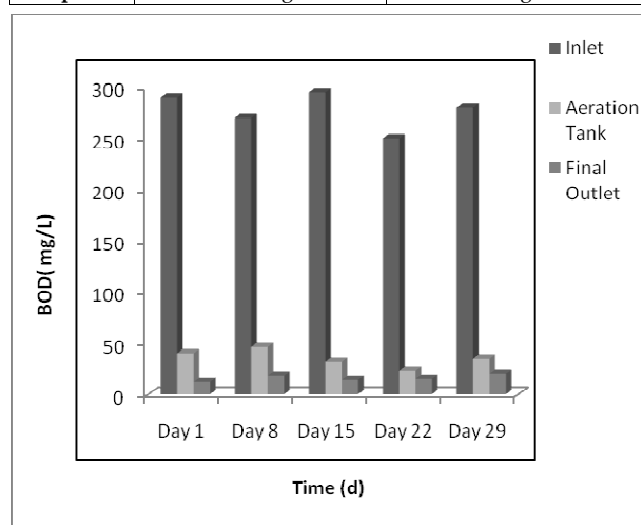


FIG. 1 BOD OF THE WASTEWATER IN VARIOUS UNITS OF STP

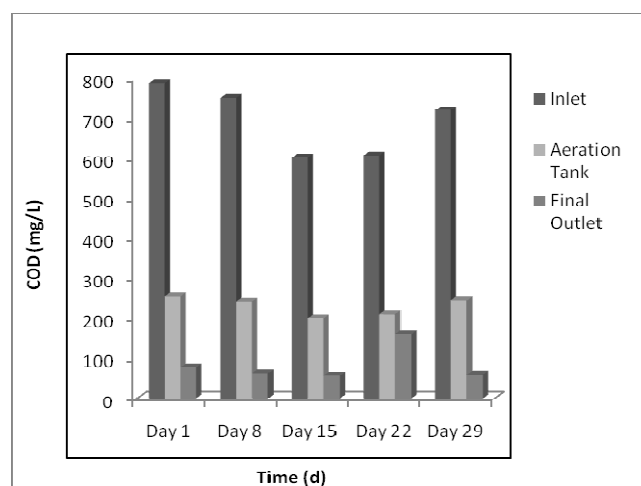


FIG. 2 COD OF THE WASTEWATER IN VARIOUS UNITS OF STP

### Performance Evaluation of the Individual Units in the STP

#### 1) BOD and COD Removal in the STP

BOD and COD of the domestic wastewater during

the various stages of treatment are represented in fig. 1 and fig. 2. BOD of wastewater in the inlet tank varied from 250 mg/L to 290 mg/L, 23 mg/L to 40 mg/L in aeration tank and final outlet BOD was 12 mg/L. There was a considerable reduction in the BOD during the treatment process. BOD removal during the study varied from 90% to 95% and the treatment system was able to achieve a maximum BOD removal of 95.86%. BOD removal of 95.86% can be attributed to the decomposition and mineralization of organic compounds [14]. The Biochemical Oxygen Demand (BOD) is the most important parameter in the treatment process design and effluent discharge or reuse [15]. Higher BOD removal may be mainly due to the higher volumetric loading higher rate than 0.3 to 0.7 Kg BOD/m<sup>3</sup>-d [7,8].

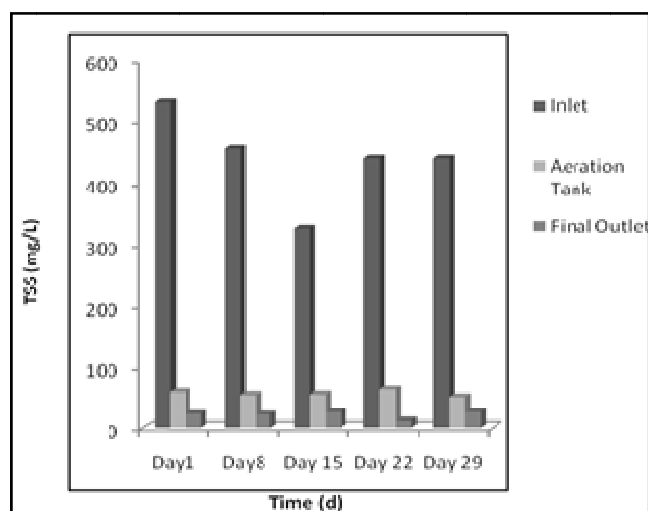


FIG. 3 TSS OF THE WASTEWATER IN VARIOUS UNITS OF STP

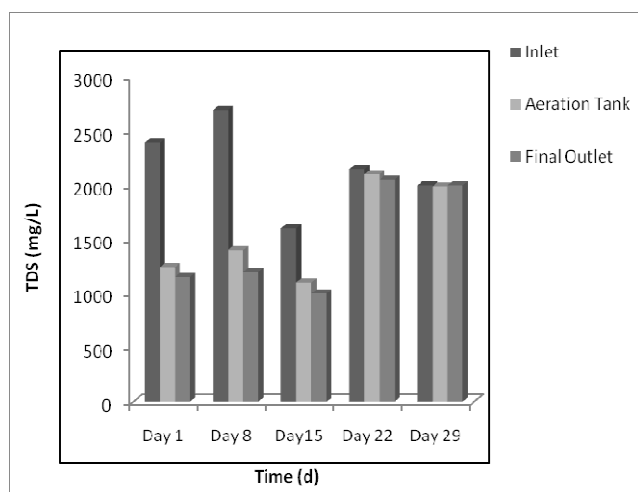


FIG. 4 TDS OF THE WASTEWATER IN VARIOUS UNITS OF STP

## 2) TSS and TDS removal in the STP

TSS and TDS removal in the various units of STP are represented in the fig. 3 and fig. 4, respectively.

TSS of the domestic wastewater in the various units of STP also showed a reduction from 553 mg/L to 23 mg/L. A maximum removal efficiency of 95.68% was observed during the study. There was slight reduction in the TDS of wastewater in the various units of STP compared to the other parameters. TDS of the wastewater in the various treatment units varied from 1600 mg/L to 2700 mg/L in inlet tank, 1100 to 1900 mg/L in aeration tank and 1000 to 200 mg/L in the outlet. A maximum removal efficiency of only 55.56 % was observed. Generally, TDS cannot be reduced in the biological wastewater treatment system. The norms for the discharge of effluent as prescribed by TNPCB are 2100 mg/L.

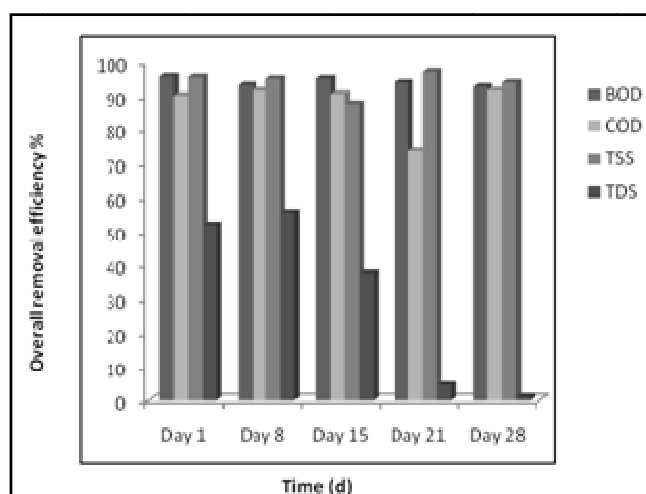


FIG. 5 OVERALL REMOVAL EFFICIENCY OF STP

The parameters like BOD, COD and TSS in the treated effluent were found to be below the prescribed range by TNPCB for most of the time during the study period (fig. 4). The percent reduction in total dissolved solids was 55% much below the expected removal of 70-80% indicating poor efficiency in terms of total dissolved solids removal. However, the removal of total suspended solids, COD, BOD was found to be satisfactory.

The influent wastewater of STP exhibited a COD to BOD ratio ranging from 2.04 to 2.78 and the values are comparable to those presented by Metcalf and Eddy (2003 and 1991) [7,8]. The typical COD/BOD ratio of domestic wastewaters is usually in the range 1.25 to 2.5. However, for treated effluents, it ranges from 2.95 to 10.6. This indicates relatively higher proportion of the nonbiodegradable content in treated effluent than raw wastewater. Hence the BOD removal efficiency is higher than that of COD [13].

Dissolved oxygen in the aeration tank varied from

2.3 mg/L to 2.5 mg/L, which was slightly above the desirable range of D.O (1.5-2.0 mg/L). MLSS/MLVSS ratio varied from 0.51 to 0.62, which was also maintained to the desirable ratio of 0.60 (table 2). F/M ratio was maintained between 0.1- 0.18 (table 3). Evaluation of operating parameters like dissolved oxygen, MLSS, MLVSS and F/M ratio of the aeration tank revealed that the treatment unit is maintained in good operating condition and hence a good removal efficiency of BOD and COD.

TABLE 2 MLVSS AND MLSS RATIO IN STP

Duration of sampling	MLSS(mg/L)	MLVSS(mg/L)	Ratio	Desirable ratio
Day 1	1994	1012	0.51	0.60
Day 8	2100	1284	0.61	0.60
Day 15	2150	1330	0.62	0.60
Day 21	2140	1240	0.58	0.60

TABLE 3 F/M RATIO in STP

Date of sampling	F/M Ratio	Desirable
Day 1	0.16	0.1 - 0.18
Day 8	0.14	0.1 - 0.18
Day 15	0.15	0.1 - 0.18
Day 21	0.15	0.1 - 0.18

### *Rhodamine B water Tracer Study*

The volume of the aeration tank was 20,184 m<sup>3</sup> and the volumetric flow rate was 6.25 m<sup>3</sup>/min, which gave the theoretical mean residence time as 960 minutes. The experimental mean residence time was 840 min, meaning that the system has approximately 12.5% dead volume. The water tracer study revealed that aeration tank achieves the designed residence time and works efficiently as far as residence time is concerned. Lesser dead volume, will be the area of stagnant zone within the aeration tank. According to Farook et al[9], a negligible volume of the stagnant zone in the aeration tank indicates that it works efficiently as far as residence time is concerned. In another study carried out in common effluent treatment plant for tannery effluent, the flaws in the aeration tank gave higher dead volume of 19.6%[10]. Rhodamine water tracer studies also revealed that the treatment system was in good condition maintaining a proper volumetric flow rate and there were no flaws in the treatment unit. Removal efficiency of the treatment unit also revealed that the unit is maintained in good condition.

### Conclusion

All the individual units in the STP were checked for their design authenticity and no flaws were found and hence the design wise the STP was found to be

satisfactory. The volumetric loading was found to be in the range of 0.30-0.33 kg BOD/m<sup>3</sup>-d, which is within the normal range of 0.30 to 0.7 kg BOD/m<sup>3</sup>/d. It was found that loading rates well enhanced the BOD removal efficiencies in the present study. Rhodamine water tracer study also revealed that the treatment system was maintained in a good condition without any flaws in the design of the treatment unit. The treatment plant was well maintained with a higher removal efficiency achieving the standards prescribed by the TNPCB.

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